Field Stability Improvement of the Kyoto University Cyclotron

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Field Stability Improvement of the Kyoto University Cyclotron

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The stabilizer of the main magnet exciting current of the Kyoto University Cyclotron was improved. Several hours stability of 5×10^{-5} was obtained.

KEY WORDS: Cyclotron / Current stabilizer /

I. INTRODUCTION

It is well known that the cyclotron acceleration requires the following relation among the magnetic field B and acceleration R. F. frequency ω; $m\omega=qB$, where m is the accelerated ion mass and q is its charge. To maintain the intensity of accelerated beam constant, stability of less than 10^{-4} is required for both ω and B from our experience.

For the excitation of the main magnet coil, 400V×125A is required and is supplied with a 400V DC generator driven by a 3KV–75KW induction motor.[1,2] The field of this DC generator was hitherto excited by a small generator of which field was excited by transistor power supply to regulate the main coil current. This method, however, did not assure the main coil current stability better than 10^{-3}. The small DC generator was replaced with a 100V×10A transistor switching power supply,[4] and good result was obtained.

II. CIRCUIT DETAILS

The circuit diagram is shown in Figs. 1–a and 1–b. The system is separated into two modules. One is an error amplifier and another is a power drive.

As the voltage standard, the LM399[3] of which the temperature stability 2×10^{-6}/°C is guaranteed, is used. Tr_1 is its current source. A chopper amplifier is constructed with IC–1 and analog SW IC–2, of which the output is integrated by IC–3 to pass only low frequency component of error signal. Tr_2 and Tr_3 are limitters against overcharging the time constant C. IC–4 works as a fast response amplifier. IC–5 is a phase-compensator for high frequency component only. IC–6 converts the height of the output signal to pulse width for the power drive. This power drive is designed carefully taking into account the low power dissipation, compactness and simplicity. The amplifier and power source system are coupled together via a photo coupler to isolate their electric potential from noise immunity.

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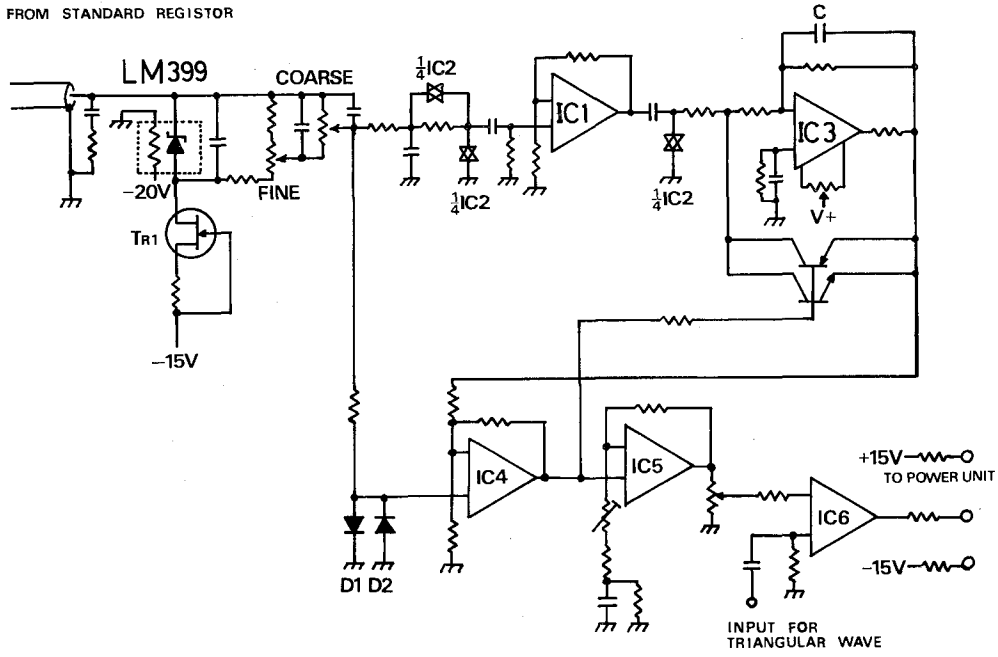
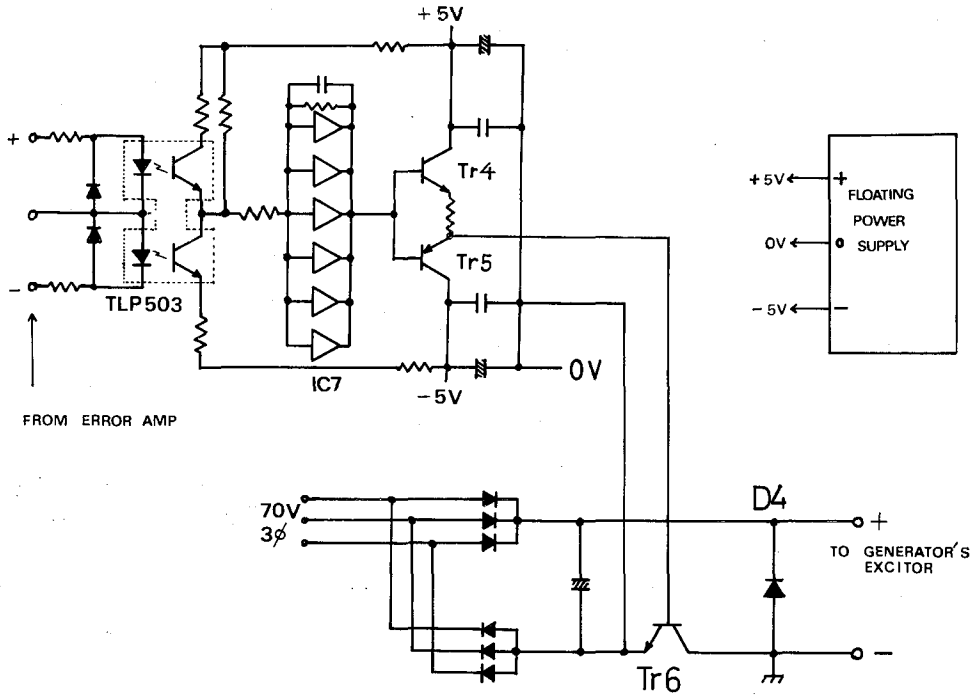


(a) Circuitry of error signal amplifier,



(b) Circuitry of power driver.

Fig. 1. Current stabilizer of the main magnet coil;

The switching frequency is 1 KHz. This frequency was chosen not to cause the ripple of the coil current. The measured bode diagram of the main coil for small amplitude is shown in Fig. 2. The coil is coupled with the motor generator, including its exciting coil, as in the mode of operation. The switching noise component beyond 1 KHz was suppressed less than -90 dB. IC–7 is used as a comparator. Tr_4 and Tr_5 drive the power switching transistor Tr_6. D4 is a flywheel diode for the switching operation. Misoperation of the system such as the switching on without cooling the coil is prevented by a built-in interlock system. Signals from the secondary cooling system of the magnet coil, its primary cooling system, and 3 KV induction motor, interlock the operation of the stabilizer.

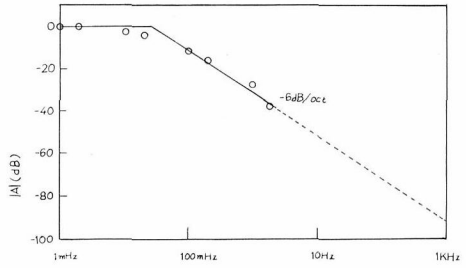


Fig. 2. Bode diagram of the main coil system.

III. PERFORMANCE

Figure 3 shows the obtained result. Less than 5×10^{-5} drift is achieved for several hours.

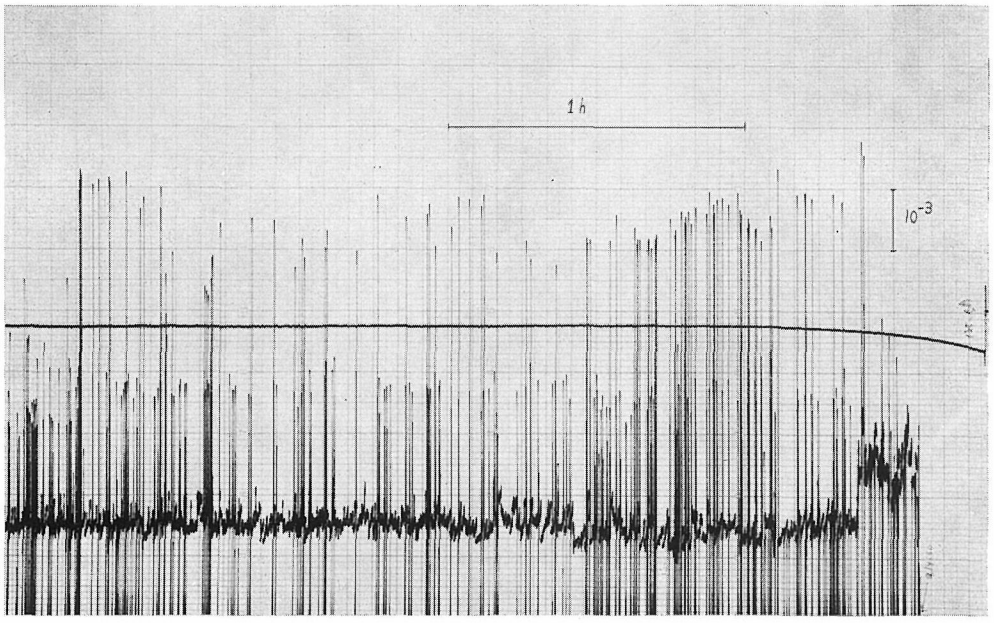


Fig. 3. Recorded error signal. Time scale and voltage division are shown in the figure.

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